Characterizing the effects of chronic 2G centrifugation on the rat skeletal system

Aimee Johnson [1], Ryan Scott[2], April E. Ronca[2], Tana M. Hoban-Higgins[3], Chuck A Fuller[3], Joshua S. Alwood[2]
1. University of Colorado Denver, 2. NASA Ames Research Center, 3. University of California Davis

University of Colorado Denver

Space Biosciences
NASA AMES RESEARCH CENTER

Introduction

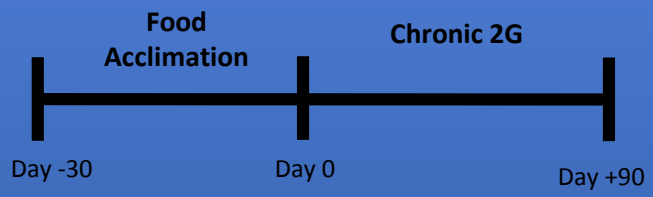
During weightlessness, the skeletal system of astronauts is negatively affected by decreased calcium absorption and bone mass loss. Therefore, it is necessary to counteract these changes for long-term skeletal health during space flights.

Aim

Our long-term plan is to assess artificial gravity (AG) as a possible solution to mitigate these changes. In this study, one of our aims is to determine the skeletal acclimation to chronic centrifugation.

Study Design

The experiment has two groups, each with an n=8: chronic 2G and 1G centrifuge-size cage control. Young adult (7 months) male Long-Evans rats were used to assess our hypothesis. This group was subject to 90 days of 2G via centrifugation performed at the Chronic Acceleration Research Unit (CARU) at University of California, Davis. After 90 days, animals were euthanized and tissues collected. Blood was drawn via cardiac puncture and the right leg collected for structural (via microcomputed tomography at 7µm) and strength quantification.



Funding/Acknowledgments
NNX16AB67G (CAF)
Space Biology PECASE (JSA)
Heinrich Gompf and Amy McElroy for experimental support.

Hypothesis

A 2G hypergravity environment causes an anabolic response in growing male rats. Specifically, chronic 2G to increase tissue mineral density, bone volume fraction of the cancellous tissue and to increase overall bone strength. Systemically, bone formation markers (i.e., osteocalcin) are elevated and resorption markers (i.e., tartrate resistant acid phosphatase) are decreased or unchanged from controls.

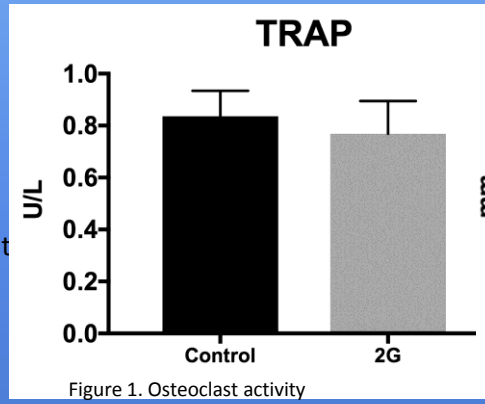


Figure 1. Osteoclast activity

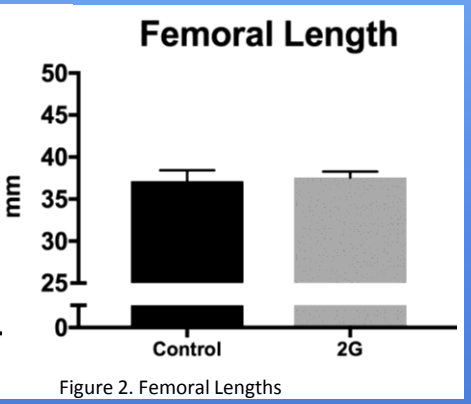


Figure 2. Femoral Lengths

Results

Through 3D image processing via SkyScan 1272 it was found there there were no significant changes in bone volume over total volume and in trabecular number when comparing the 2G rats to the control rats. Tartrate resistant acid phosphate (TRAP), an enzyme expressed in osteoclasts and a marker of bone resorption, was quantified in serum though showed no significant difference.

Conclusion

Data suggest that 2G did not lead to cancellous changes in the distal femur, nor osteoclastogenic activity, at 90 days of exposure. Thus, we conclude that the cancellous bone of the Control and 2G animals appear to develop to the same endpoint within 90 days of centrifugation.

Future Direction

Look at the kinetics and run a series of 2G experiments and obtain DXA scans. Overall better understand the implications of mechanical loading on the skeletal system. Add female cohort.

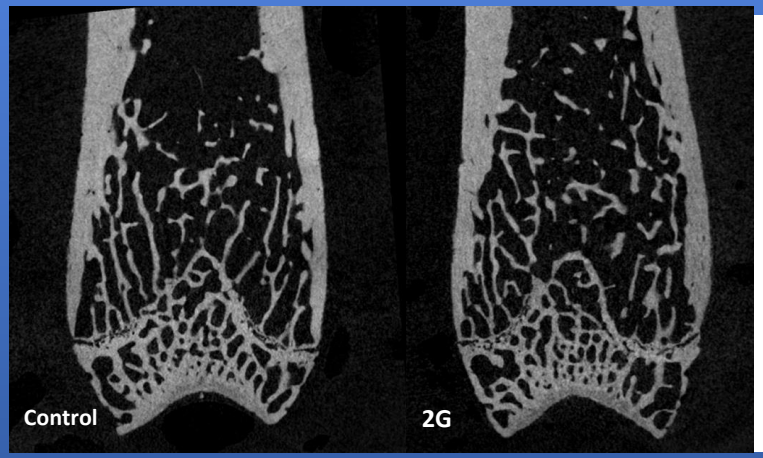


Figure 3. Control & 2G Distal Femur Image

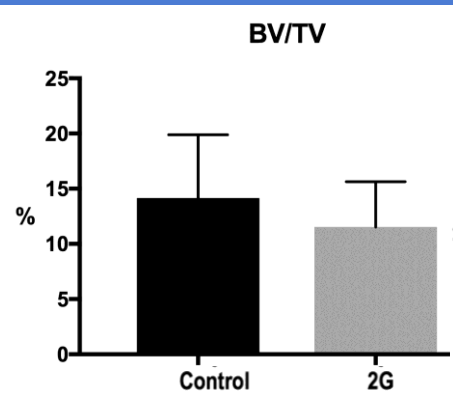


Figure 4. Bone Volume/ Total Volume

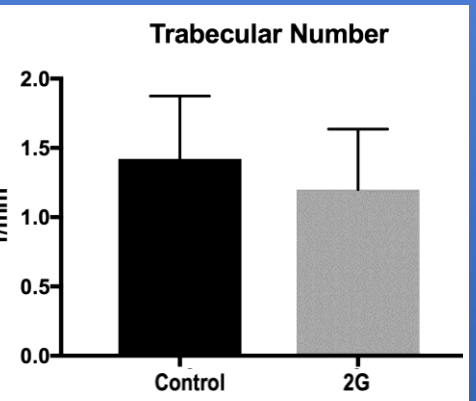


Figure 5. Trabecular Number